Question 6: Portfolio Construction

Austin Byrne[1]

Abstract

In this question I create optimal portfolios making use of Minimum Variance Optimization. I first construct a unconstrained portfolio and then compare it to the constrained portfolio. The constrained portfolio results in lower risk and lower return.

1. Introduction

In this question I dive into the realm of portfolio construction. To create an optimal portfolio I make use of the Minimum Variance Optimizer (MVO) which creates an optimal portfolio with the lowest possible variance. I construct an unconstrained and constrained portfolio using MVO. The resulting optimal portfolios are low risk low return portfolios which can be expected from using MVO. The constrained optimal portfolio results in lower risk and lower annualized monthly returns.

1.1. Laod relevant functions

I load any function that I may have created so that I can use them in this code and analysis.

1.2. Loading relevant data and packages

Here I load the relevant data.

1.3. Data preperation: Lets convert the price data to monthly returns data

In this section I do some data perpetration. I take the original data of the MAA and msci and create a new column called Monthly_returns, which calculates the monthly returns from the daily data. I also filter for post 2010 and ensure that at least three years a data is available.

Email address: (Austin Byrne)

1.3.1. MAA monthly returns

Monthly returns for MAA are calculated after some fun wrangling.

1.3.2. msci monthly returns

Monthly returns for msci are calculated after some fun wrangling.

1.3.3. Creating an asset class column in my data sets

There are now four different asset classes in the MAA data set, namely, "Asian currency", "Credit", "Rates", "Commodity", "Equity", and "Real estate.

1.4. Lets now attempt to construct the portfolio by making use of minimum variance optimization:

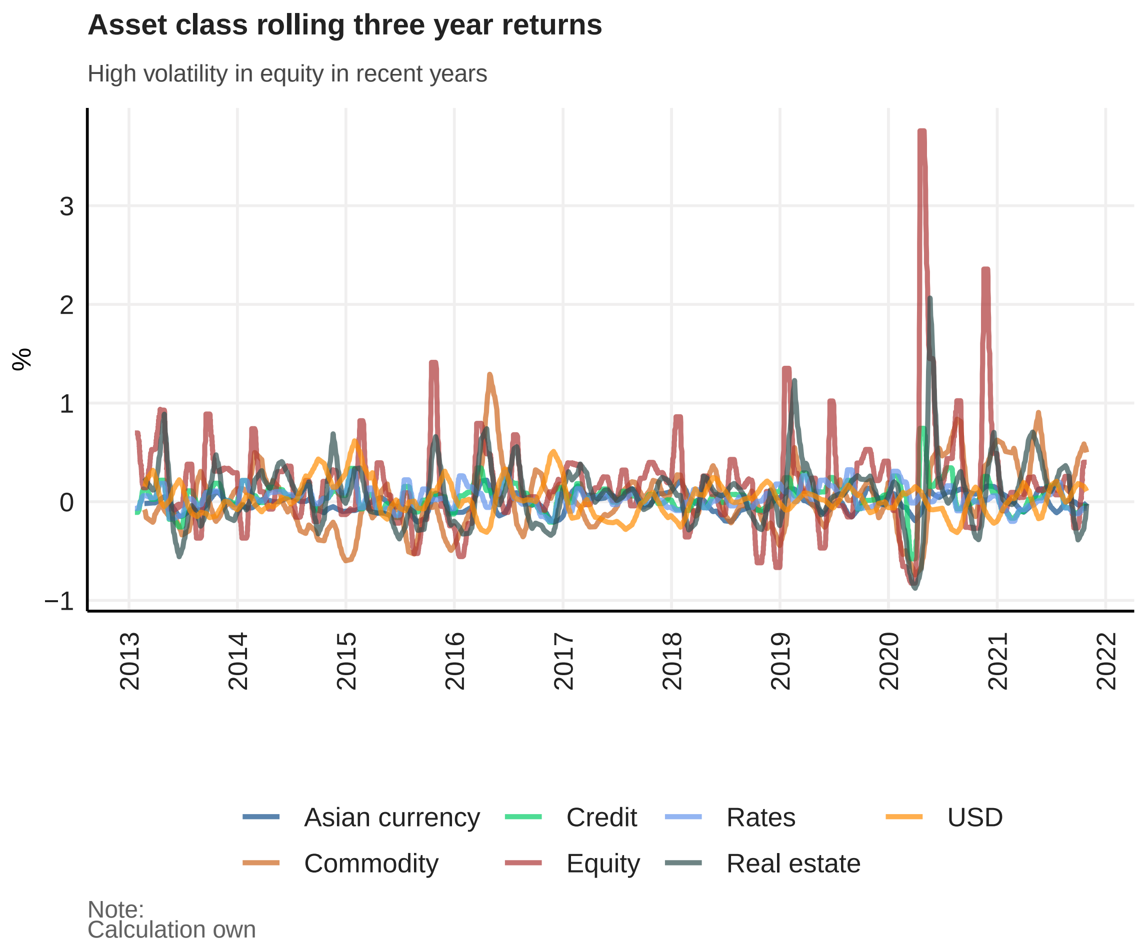
I now make use of Minimum Variance Optimization to first create a unconstrained portfolio. I am then able to evaluate the risk and return of the unconstrained portfolio which I then compare to the constrained portfolio.

1.4.1. Combine the Data Sets and compute some graphs

Here I make use of a function I created that prepares and combines the relevant data.

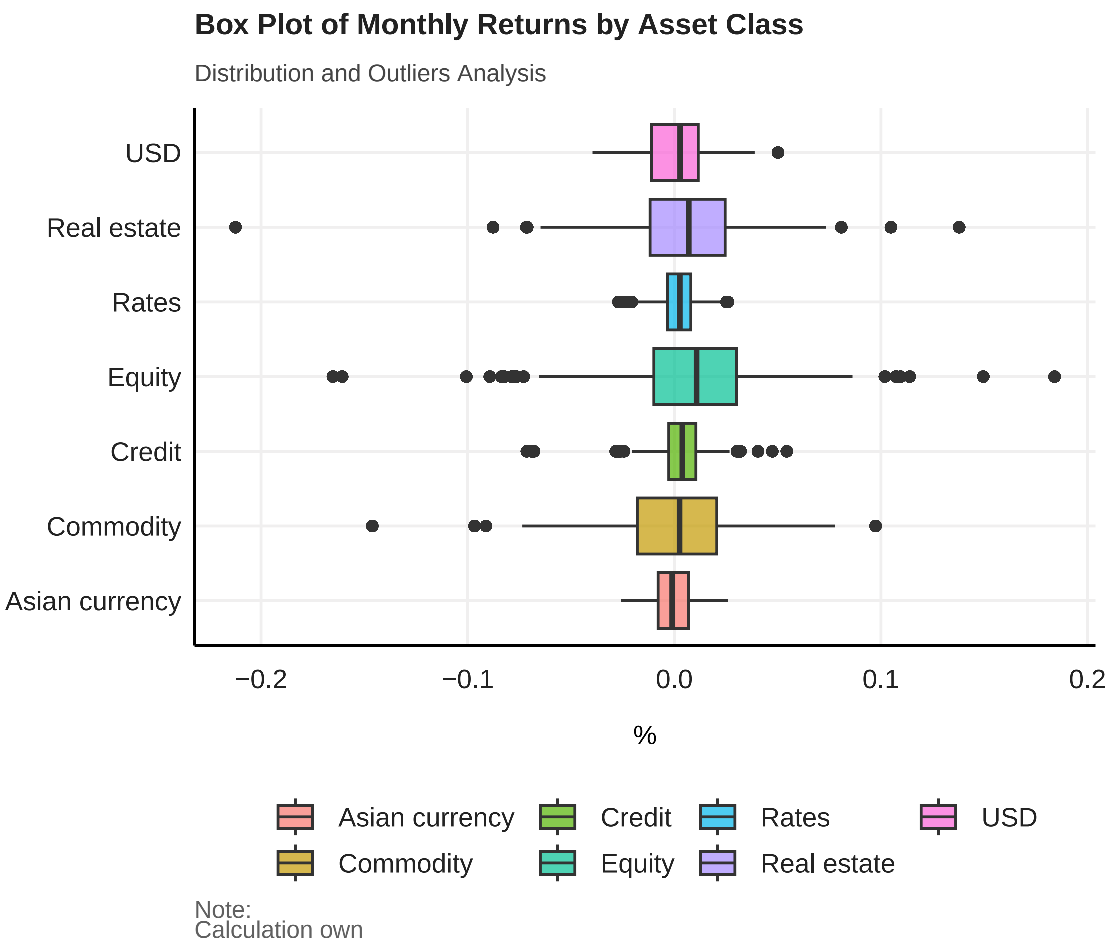
1.4.2. Rolling 3 year annualzied returns comparison of asset classes

TO inspect the data in question I run a plot that contains the 3 year annualized returns for each asset class. What is immediately evident in this plot is that the equities asset class is the most volatile which also means the asset class that potentially holds the most risk. Outside of the equities asset class, the remaining asset classes are relatively similar, with USD being the next most volatile.



1.4.3. Boxplot of monthly returns by Asset class

Here I make use of a function I create to obtain the box plot for each asset class which illustrates the distribution of monthly returns for each asset class. The equity asset class as expected has the highest average monthly return but also contains a lot of outliers which can be expected after seeing how volatile the returns of equity can be. The most stable asset classes seem to be the Asian currency and USD. This plot creates a nice illustration of the spread of monthly returns for each asset class.



1.4.4. Computing the returns matrix

In order to using the Minimum Variance Optimizer I need to first create a returns matrix, which contains the returns of each asset class in a matrix. TO do this I make use of a function that was crated in the practical.

1.4.5. Computing the simple covariance matrix

Like that of the returns matrix one needs to create a simple covariance matrix to make use of MVO and be able to create an optimal portfolio.

1.4.6. Using Minimum variance optimization (MVO) for an unrestricted portfolio.

Now using MVO I am able to construct an unconstrained optimal portfolio and evaluate the risk and returns. The risk will be evaluated by the standard deviation.

As can be seen from the table below, The optimal unconstrained portfolio has a standard deviation of 0.09827125 and an average annualized monthly return of 0.02648242. Thus the portfolio has a very low standard deviation which is expected since the portfolio was constructed using MVO. Since the portfolio takes on low risk, it is not surprising to see that the return is also fairly low at 0.02648242. Thus, the unconstrained optimal portfolio using MVO is a low risk low return portfolio.

Lets now add the constraints in and then compare to this base portfolio.

```
## # A tibble: 1 x 2
##   average_ret_Ann volatility_Ann
##             <dbl>          <dbl>
## 1          0.0265         0.0983
```

1.4.7. Now lets create the constrained optimised portfolio

With the specific constraints being: Apply Quarterly Rebalancing; - Limit exposure to Bonds and credit instruments at 25%; - Limit exposure to Equities at 60%; - Limit single asset exposure at 40%

1.4.7.1. Lets first create some bond/credit and equity idicies that we can use for our constraints later. Here I create the constraints that will be used to construct the constrained optimal portfolio.

#Adding constraints to the optimisation problem and solving

Solving for the constrained optimal portfolio is done using the CVXR package in R.

Lets now evaluate the constrained portfolio. The constrained optimal portfolio is an even lower risk and lower retun portfolio than that of the unconstrained portfolio created previously. The standard deviation is now at 0.0003147487 and the monthly annualised return is at 0.0003147487. Thus by adding the constrains to the portfolio we decrease the risk in the portfolio through decreased standard deviation, however, with decreased risk come decreased returns. Once again since we make use of MVO to create the optimal portfolio, it is not surprising that the optimal portfolio is a low risk low return optimal portfolio.

```
##       [,1]
##  [1,] 0.01
##  [2,] 0.01
##  [3,] 0.01
##  [4,] 0.01
```

```
##  [5,] 0.01
##  [6,] 0.27
##  [7,] 0.01
##  [8,] 0.40
##  [9,] 0.01
## [10,] 0.01
## [11,] 0.01
## [12,] 0.01
## [13,] 0.23
```

```
## # A tibble: 13 x 2
##    stocks         weight
##    <chr>           <dbl>
##  1 ADXY Index       0.01
##  2 BCOMTR Index     0.01
##  3 DXY Index        0.01
##  4 LEATTREU Index   0.01
##  5 LGAGTRUH Index   0.01
##  6 LGCPTRUH Index   0.27
##  7 LP05TREH Index   0.01
##  8 LUACTRUU Index   0.4
##  9 LUAGTRUU Index   0.01
## 10 MSCI_ACWI        0.01
## 11 MSCI_Jap         0.01
## 12 MSCI_RE          0.01
## 13 MSCI_USA         0.23
```

```
## [1] 0.0003147487
```

```
## [1] 0.005250953
```

Table 1.1: Portfolio Performance Metrics

Metric	Value
Annualized Return	0.0052510
Annualized Risk	0.0003147

References

Appendix

Appendix A

Some appendix information here

Appendix B